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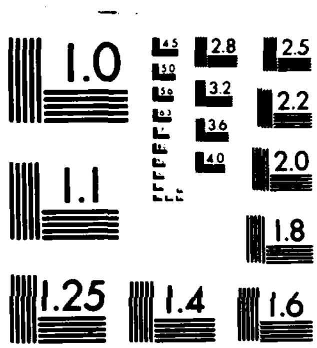

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NATO/LONDON MATHEMATICAL SOCIETY ADVANCED STUDY INSTITUTE ON SYSTEMS OF NONLINEAR PARTIAL DIFFERENTIAL EQUATIONS

R.L. STERNBERG
Office of Naval Research, Boston, MA

28 February 1983

UNITED STATES OF AMERICA

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Major topics at the conference included problems in nonlinear elasticity, applications of bifurcation to mechanics, analysis and computational fluid dynamics, nonelliptic problems and phase transitions, and dynamical systems and practical differential equations.

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NATO/LONDON MATHEMATICAL SOCIETY ADVANCED STUDY INSTITUTE ON SYSTEMS OF NONLINEAR PARTIAL DIFFERENTIAL EQUATIONS

NATO, The London Mathematical Society, and the US Army Research, Development and Standardization Group (UK) sponsored an Advanced Study Institute on Systems of Nonlinear Partial Differential Equations. The institute was held at Oxford Univ. from 25 July to 7 August 1982.

Attendance was by invitation and was limited mainly to about 100 university mathematicians selected from NATO countries. About 20 participants were from the United States. The principal organizer was Prof. John Ball (Heriot-Watt Univ., Edinburgh).

In addition to a number of short general courses on nonlinear partial differential equations and systems of such equations, there were five special sessions on more narrowly defined topics: "Problems in Nonlinear Elasticity," "Applications of Bifurcation Theory to Mechanics," "Analysis and Computational Fluid Dynamics," "Nonelliptic Problems and Phase Transitions," and Dynamical Systems and Partial Differential Equations."

Nonlinear Elasticity

Prof. R.J. DiPerna (Duke Univ.) opened the first session with a talk on "Conservation Laws," in which he discussed the convergence of singular perturbations for conservation laws of the hyperbolic and elliptic type. Topics covered included the "viscosity" method, difference schemes, and "large data" existence theorems. Following DiPerna was a presentation by Prof. M. Potier-Ferry on "Constitutive Inequalities and Dynamic Stability in the Linear Theories of Elasticity, Thermoelasticity, and Viscoelasticity"; various stability and instability theorems were established for the three types of elasticity.

Prof. R.V. Kohn (Courant Institute) then spoke on "The Incompressible Limit in Nonlinear Elasticity." Initial value problems for a family of slightly compressible hyperelastic materials characterized by suitable stored energy functions were studied, with the treatment limited to space-periodic problems in appropriate Sobolev spaces. Following Kohn were talks on "Group Theoretic Classification of Conservative Laws in Elasticity," "Stability of the Elastica," and "Coercivity Conditions in Nonlinear Elasticity" given, respectively, by Prof. P.J. Oliver (Univ. of Minnesota), Prof. J. Maddocks (Stanford Univ.), and Prof. S.S. Antman (Univ. of Maryland).

Bifurcation Theory

The first speaker at the second session was Prof. J.F. Toland (Univ. of Bath) who reported on "Bifurcation in $R \times L_p$ for Singular Problems." The discussion focused on the phenomenon of bifurcation of solitary-wave-type solutions from a line of trivial solutions in $R \times L_p$ for three types of singular eigenvalue problems, including a nonautonomous ordinary differential equations problem, an autonomous ordinary differential equations problem, and a nonautonomous partial differential equations problem. The first was a version of the Korteweg-DeVries solitary wave problem, the second a Boussinesq-type model for water waves due to Bona and Smith, and the third a primitive prototype of the nonautonomous partial differential equations problems that arise in mathematical analysis

of propagation of internal waves. The next paper, by Prof. E.N. Dancer (Univ. of New England in Australia), was entitled "Bifurcation Under Continuous Groups of Symmetrics" and dealt with abstract matters relating bifurcation phenomena to group theory.

The remaining three papers in the session were by Prof. J. Carr (Heriot-Watt Univ.), Prof. J. Mallet-Paret (Michigan State Univ.), and Prof. J.E. Marsden (Univ. of California, Berkeley), who spoke respectively on "Phase Transitions via Bifurcation from Heteroclinic Orbits," "Singularly Perturbed Delay Equations in Optical and Biological Models," and "Symmetry and Bifurcation in Three-Dimensional Elasticity."

Fluid Dynamics

In the third session, Prof. O. Hald (Univ. of California, Berkeley) spoke on "Inverse Eigenvalue Problems for the Mantle." He showed that if the density in the earth's lower mantle is known, one can reconstruct the density in the upper mantle numerically from information on the velocity of the s-waves and one torsional spectrum. Prof. A. Majda (Univ. of California, Berkeley) described "The Design and Numerical Analysis of Vortex Methods" and detailed recent progress in vortex methods as applied to incompressible fluid flow in two or three space dimensions.

Vortex methods, it was noted, have several attractive computational advantages over and above conventional finite difference or finite element methods. Vortex methods have been developed especially for simulation of flows at high Reynolds number and simulation of inviscid fluid flows. Prof. A.J. Chorin (Univ. of California, Berkeley) discussed "Vortex Methods for Boundary Layer Analysis" and explained the technique of vortex methods for the mathematical analysis of laminar and turbulent boundary layers.

Nonelliptic Problems and Phase Transitions

The first paper of the fourth session was by Prof. B. Dacorogna (Ecole Polytechnique Federale, Lausanne) and was entitled "Relaxation of Non-Convex Variational Problems." Dacorogna demonstrated that under certain conditions, nonconvex variational problems are equivalent to so-called relaxed problems in the sense that minimizing sequences of the original problem are weakly convergent to solutions of the relaxed problem. He noted certain applications to phase transition in Van der Waal's gases.

The second and third papers, by Prof. N. Fusco (Univ. di Napoli) and Prof. J.A. Nohel (Univ. of Wisconsin), were entitled "Remarks on the Relaxation of Integrals of the Calculus of Variations" and "A Nonlinear Diffusion Equation With a Nonmonotone Constitutive Function." The last paper of the session was by Prof. M. Slemrod (Rensselaer Polytechnic Institute), "On The Role of Korteweg Theory in the Admissibility of Shocks." Slemrod revised the manner in which Korteweg's theory of capillarity may be applied to the study of shock wave structure and showed how the Korteweg theory can be used to explain the dynamics of phase transitions as well as shockwave structure in classical fluids.

Dynamical Systems and Partial Differential Equations

In the fifth session Prof. P. de Mottoni (Univ. degli Studi dell Aquila) spoke about "Monotone Methods for Semilinear Parabolic Equations With Density Dependent Diffusion." For some

of these equations, de Mottoni established comparison theorems for upper and lower solutions and various existence and stability properties. In addition, applications to equations on population dynamics were noted.

Prof. M.G. Crandall (Univ. of Wisconsin, Madison) discussed "Solutions of the Porous Medium Equation in R^n Under Optimal Conditions on Initial Values." He established a "best possible" existence theorem, extending an earlier result of Aronson and Caffarelli for complicated initial value problems of the type considered.

Prof. C.W. Bardos (Univ. Paris-Nord) treated the subject "Generalization of the Two Dimensional Euler Equation." The "generalization" comprised assumptions that the fluid vector field considered is not everywhere tangent to its boundary and that the domain considered is time dependent. Under the assumptions, certain new results of a somewhat complex character were developed for the classical two-dimensional Euler equation of fluid mechanics. It was noted in particular that smooth solutions still exist if the domain considered "increases" fast enough.

Prof. N. Alikakos (Purdue Univ.) gave a paper titled "Remarks on Invariance for Reaction-Diffusion Equations." He discussed his "invariance" theorem for reaction-diffusion equations in terms of (1) the physical properties related to the thermodynamics of irreversible processes, and (2) the algebraic problem of obtaining estimates on the eigenvalues of the Jordan product C = AB + BA for Hermitian positive semidefinite matrices A and B. For the latter problem, Alikakos suggested certain improvements on a previous result by Strang and Nicholson. Finally, he scrutinized a specific example of a system of reaction-diffusion equations regarding the stabilization of solutions as time increases indefinitely.

The final paper, by Prof. J.K. Hale (Brown Univ.), was entitled "Stable Equilibria in Parabolic Equations." Hale discussed the problem of obtaining stable, nonconstant equilibrium solutions for certain types of scalar parabolic equations in several space dimensions. Primary and secondary bifurcations from a constant solution are used, depending on the choice assigned to a suitable parameter and assuming Neumann boundary conditions.

The papers presented at the institute will be published in a NATO book of conference proceedings edited by Prof. John Ball and the other organizers of the institute.